eclipseCON™ 2008

Analyzing Java Performance Using Hardware Performance Counters

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Agenda

AMD Java Labs

Hardware Performance Counters

A Workload To Profile

Profiling using hprof

Profiling with CodeAnalyst™

Profiling with CodeSleuth

Demo

Demo closure

Q&A

AMD Java Labs

An engineering team within AMD dedicated to improving Java performance on AMD processors

- Provide feedback/assistance in optimization work to JVM vendors
- Create/Evaluate Java performance related tools
- Provide benchmark analysis (SPEC member)
- Routing community feedback to silicon designers to improve future products
- Participate in Java and open source communities

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What Are Hardware Performance Counters?

- Programmable counters inside the processor
- Accessed via device drivers (not from user mode)
- Can generate interrupts when trigger value is reached
- System-wide

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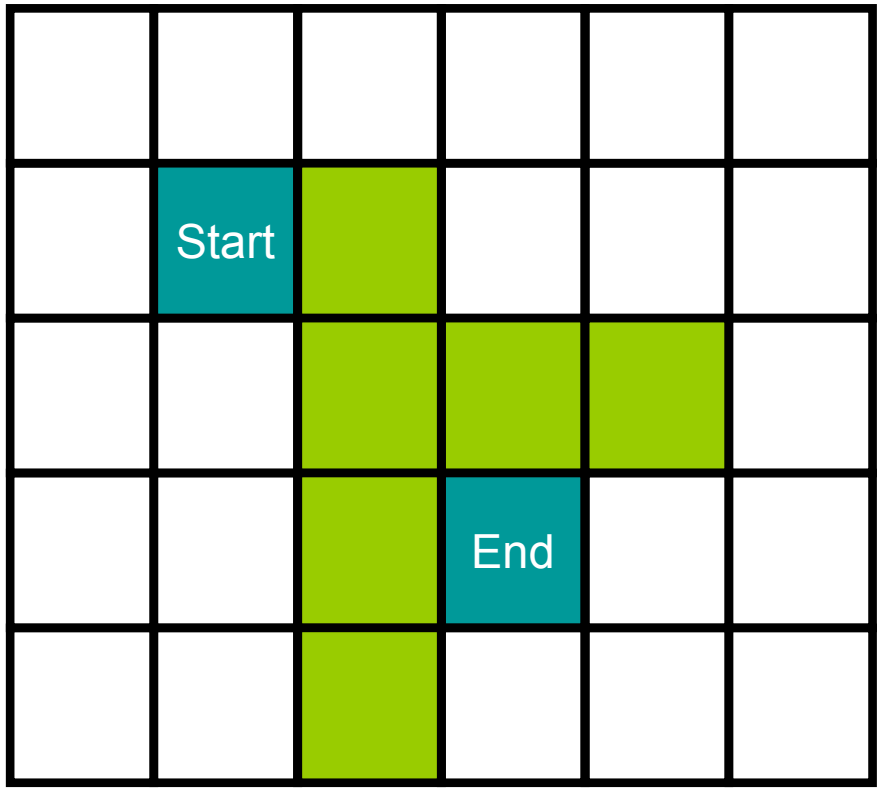
How Performance Counters Can Help Java Developers

- Understand what the processor is really doing with your code
- Help isolate cause of bottlenecks
- Provide detail that JVM based profilers can not
  - hprof takes you to the method, but not **into** the method
- No need to inject instrumentation
- Help developers make informed code and algorithm choices
- Measure and analyze as you develop code

A Workload To Profile

Find path between start and end avoiding obstacles using ‘Lee routing algorithm’



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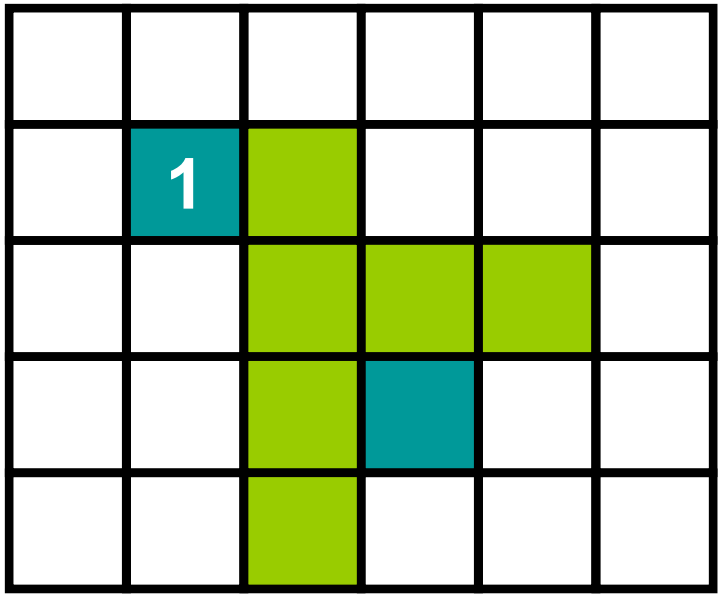
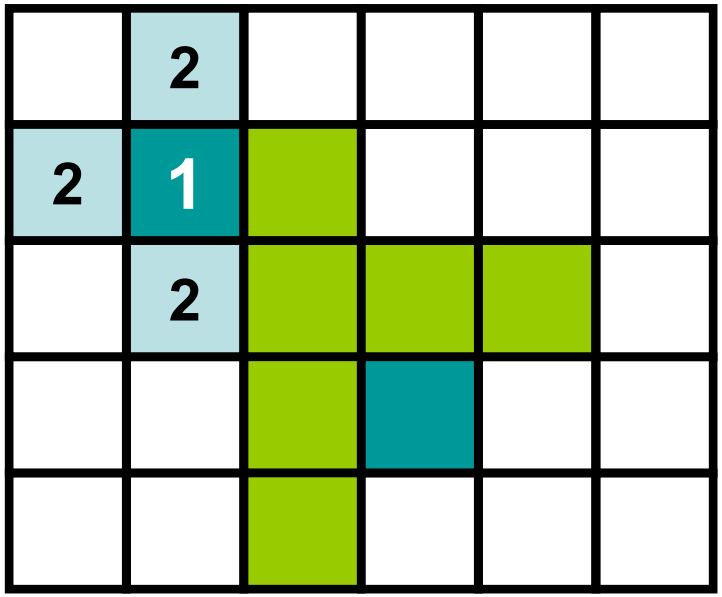
Mark starting cell with 1



for each cell with number ‘n’

mark adjacent empty cells ‘n+1’

until end marked | no empty cells



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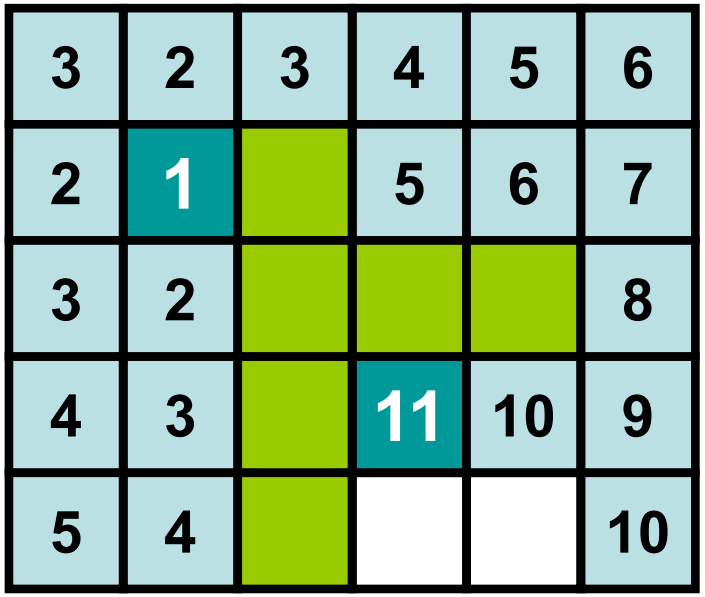
Eventually...

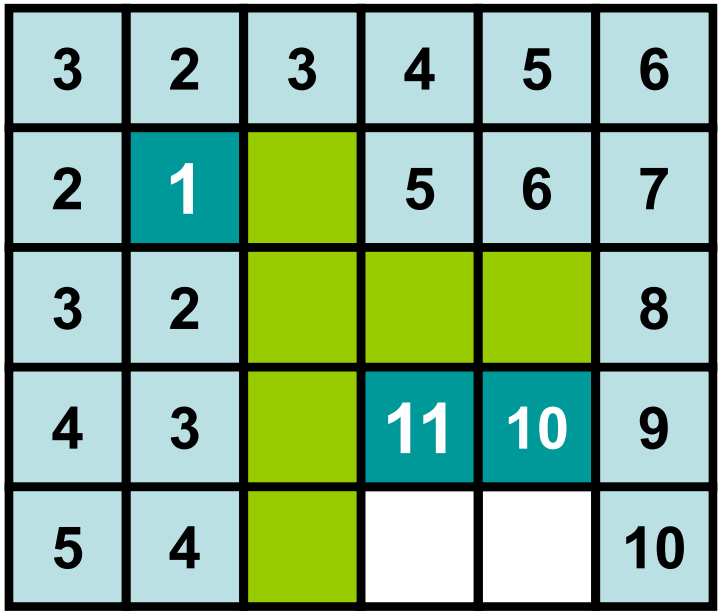


Step onto end cell

while (n!=1)

mark as part of path

step on adjacent cell (n-1)



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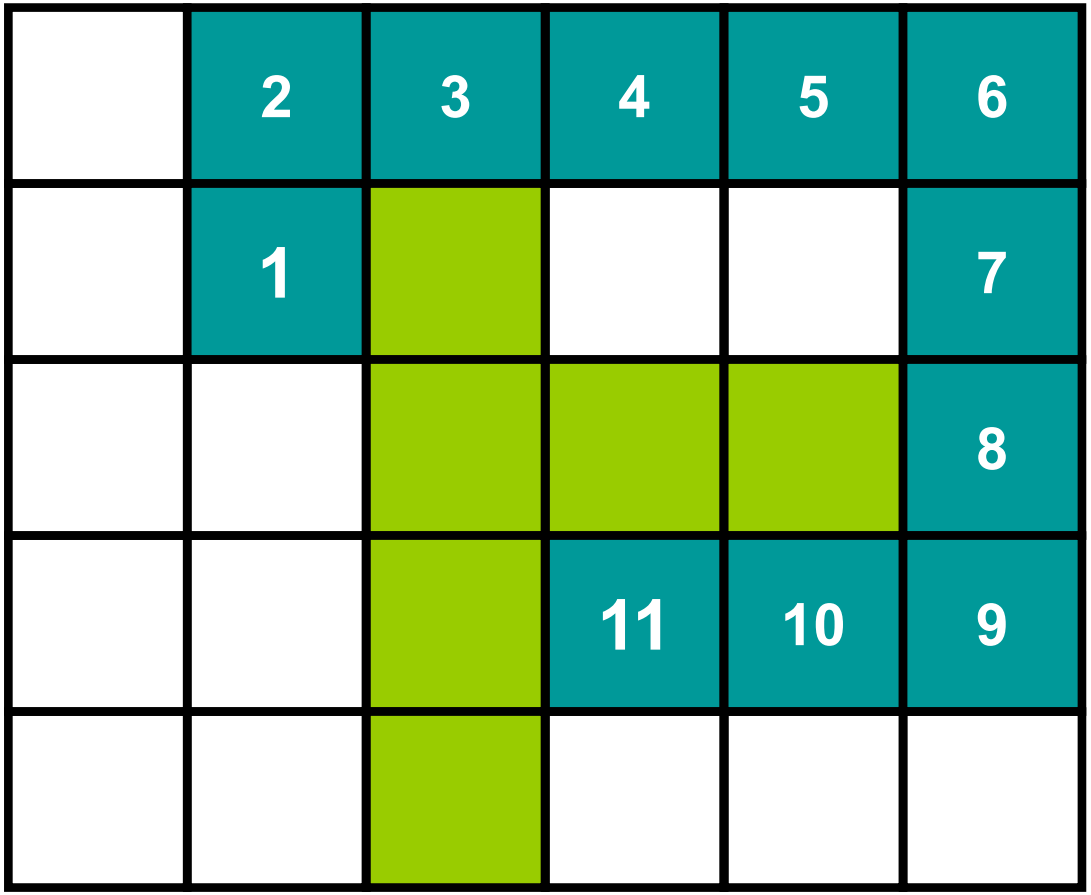
Voila !



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Profiling with hprof

Shipped with the JDK easy to use command line tool

```
java -agentlib:hprof=cpu=samples -cp lee.jar lee.Main
```

Creates a report

```
rank self accum method
   1 93%  93%   lee.Grid.flood
   2  2%  95%   java.lang.AbstractStringBuilder.append
   3  2%  97%   java.util.Collections.unmodifiableList
   4  2% 100%   sun.nio.cs.UTF_8.newDecoder
```

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hprof

- Reports how much time was spent on various call paths (stacks traces) to a method

But

- Does not tell us where within the method the time was spent
- Does not expose what happens in code emitted by the JIT (compiled methods)

hprof is representative of many Java profilers in that it is limited by the information that can be extracted from the JVM.

How AMD's CodeAnalyst™ Can Help

CodeAnalyst™ is a profiling tool which can access hardware performance counters

- Timer- or Event-based Profiling
- Linux 32- and 64-bit and Microsoft® Windows® 32- and 64-bit OSs
- Free! (http://developer.amd.com/tools)
- Maps performance data to address and source (C++/C/Java)
- Includes code emitted by the JIT

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CodeAnalyst From The Command Line

- Coordinate the launching of an executable

```
caprofile /s /l java -cp my.jar -agentlib:CAJVMTIA32 MyApp
```

- Profiler (`caprofile`) collects event data
- JVMTI agent (`CAJVMTIA32`) collects JIT data
- Correlates and creates reports

```
cadataanalyze
careport /i profile.tbp.dir/profile.tbp /m MyApp
```

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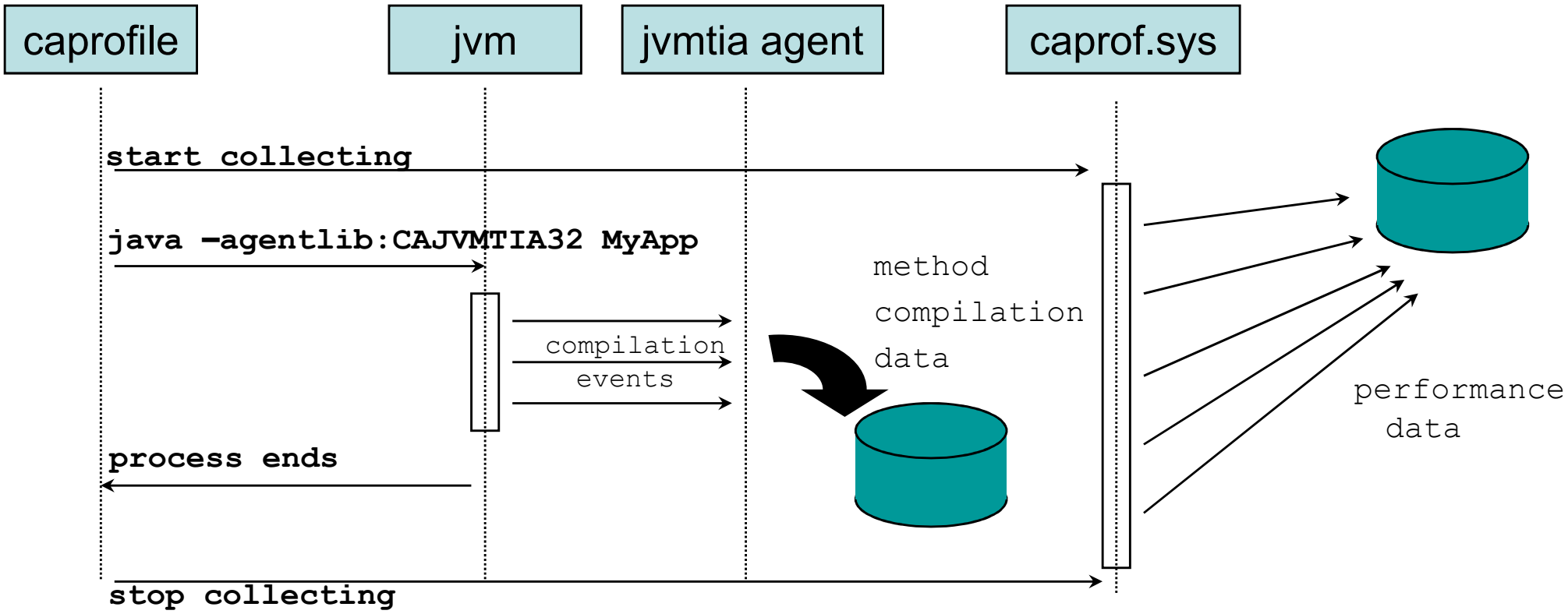
CodeAnalyst

caprofile /s /l java –cp my.jar –agentlib:CAJVMTIA32 MyApp



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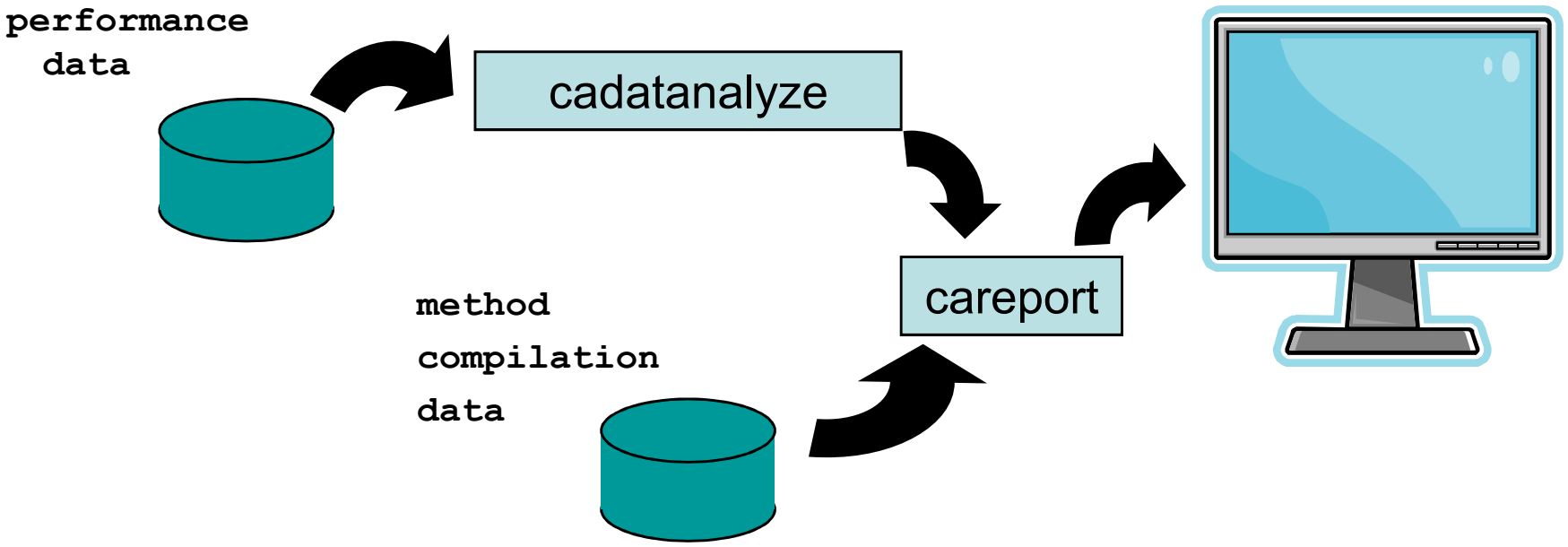
CodeAnalyst

cadataanalyze

careport /i profile.tbp.dir/profile.tbp /m MyApp



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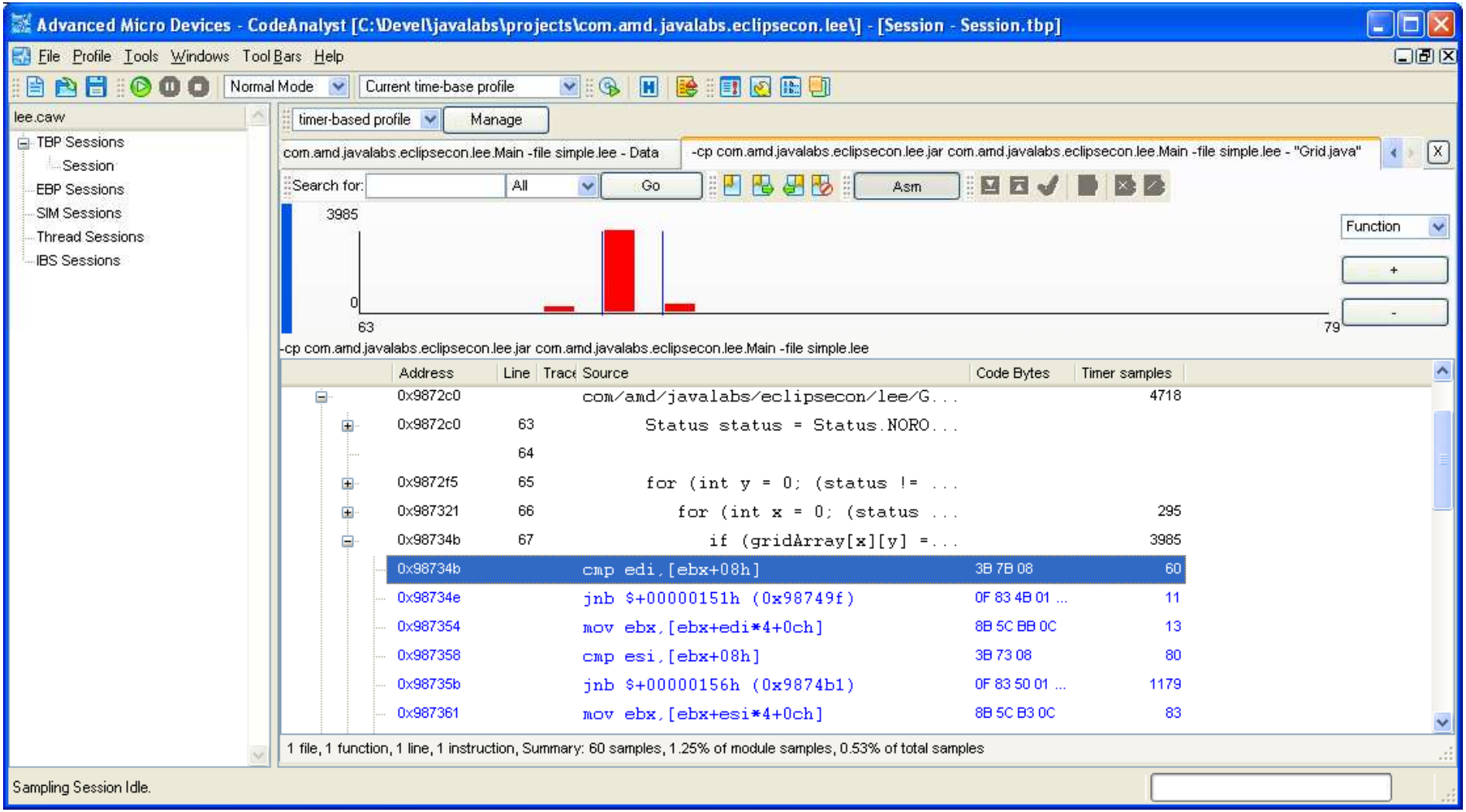
CodeAnalyst

- Event data, addresses, and methods

```
vma              Timer    % total Name
0x9877c0         24269    56.00   lee/Grid::flood
  0x98781b           1     0.00
    ...
  0x98784d        6132    14.28
  0x987853         474     1.10
  0x987857       13135    30.58
  0x987859         402     0.94
    ...
```

 |

CodeAnalyst UI



CodeSleuth

- Open Source (EPL)
- Brings various CodeAnalyst ‘views’ into Eclipse
- More natural for Java developers
  - Same IDE we are used to
  - SourceView is your Java editor
  - ‘Markers’ indicate event data we can expand
  - Configure CodeAnalyst ™ parameters in Launch Configuration
  - Cross reference architecture documentation from within IDE
- Makes Java analysis easier

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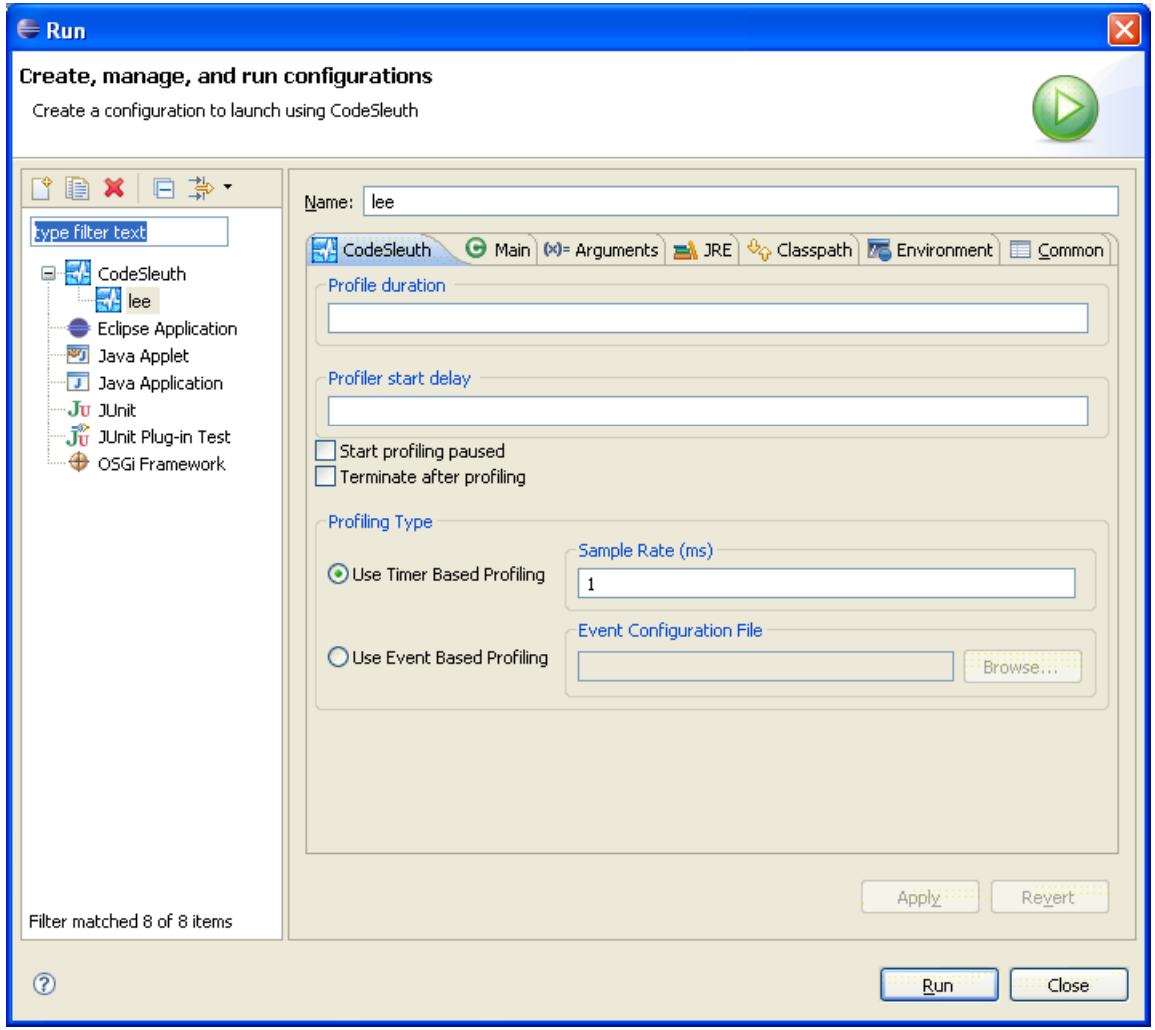
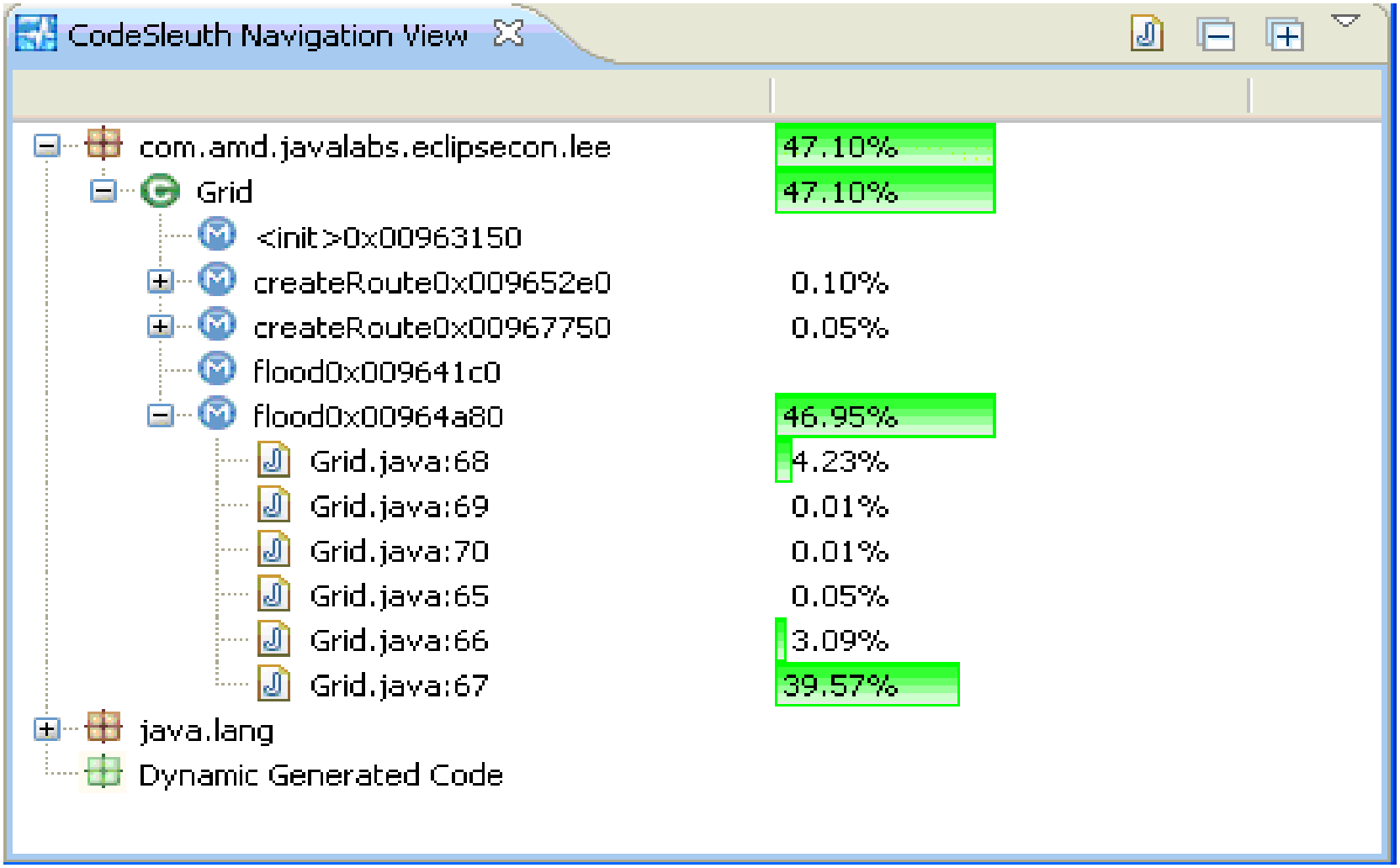
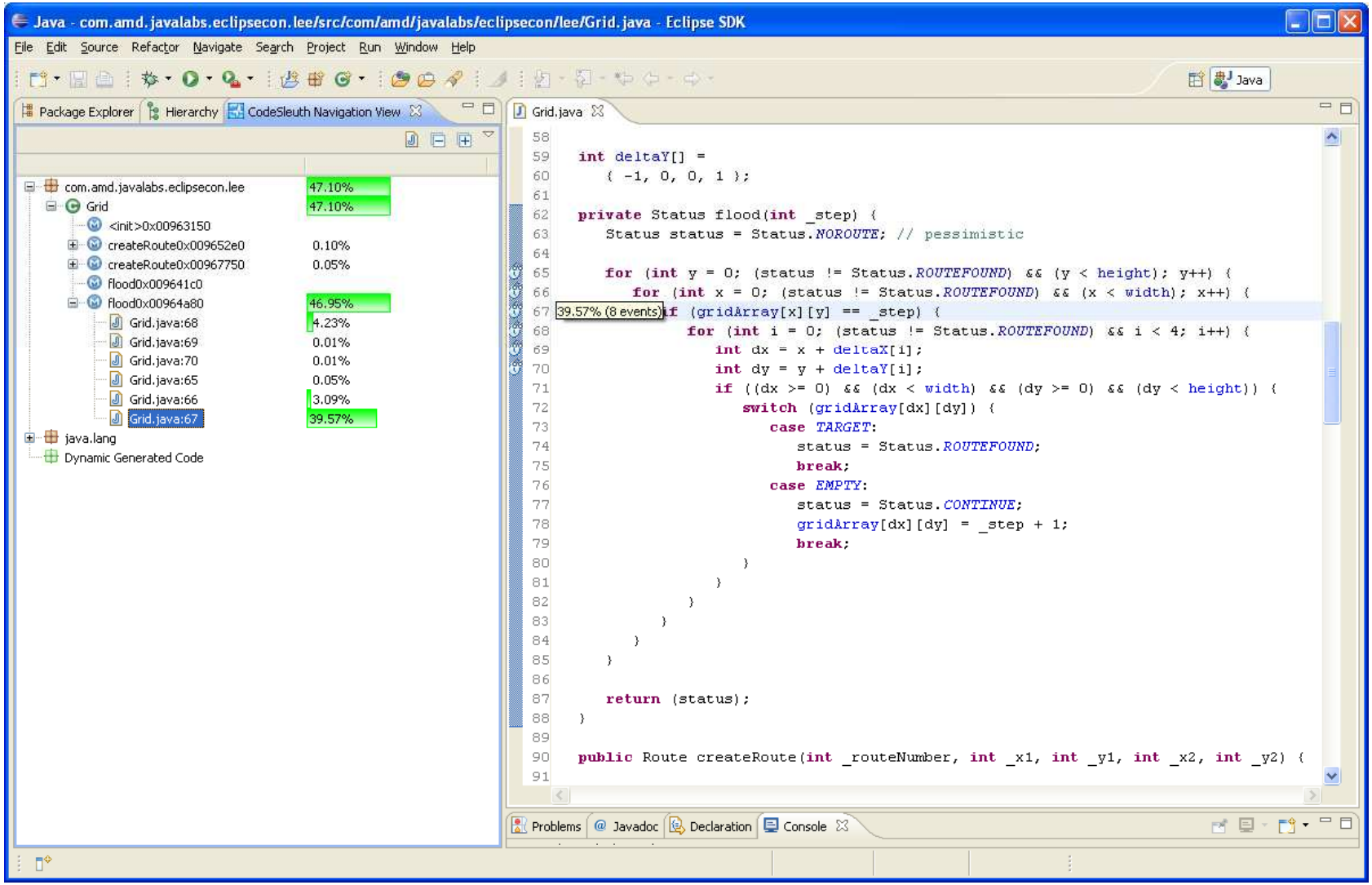
CodeSleuth Run Configuration



CodeSleuth Navigation View



Linking views to Java source



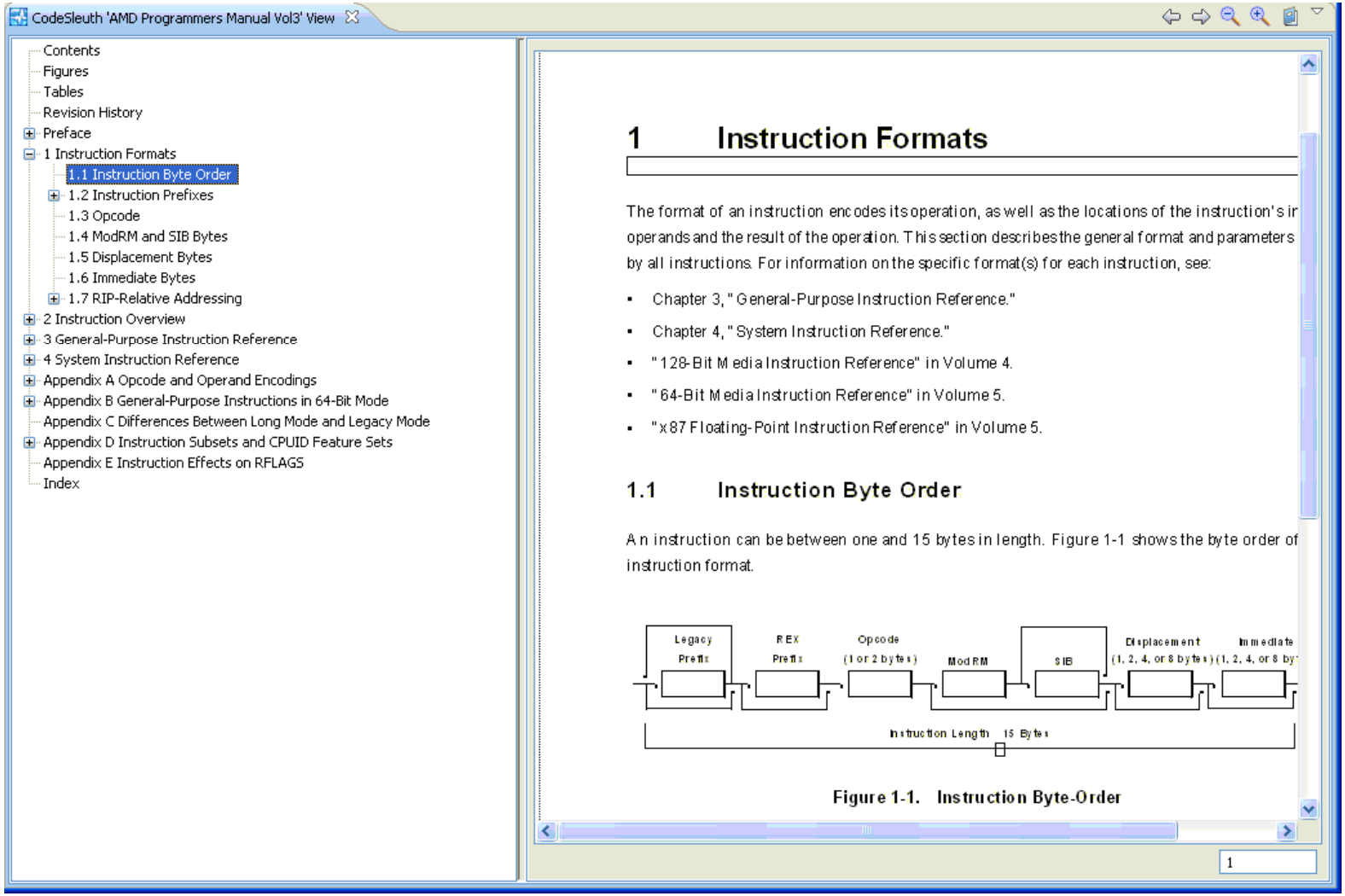

```
58
59  int deltaY[] =
60     { -1, 0, 0, 1 };
61
62  private Status flood(int _step) {
63     Status status = Status.NOROUTE; // pessimistic
64
65     for (int y = 0; (status != Status.ROUTEFOUND) && (y < height); y++) {
66        for (int x = 0; (status != Status.ROUTEFOUND) && (x < width); x++) {
67           if (gridArray[x][y] == _step) {
68              for (int i = 0; (status != Status.ROUTEFOUND) && i < 4; i++) {
69                 int dx = x + deltaX[i];
70                 int dy = y + deltaY[i];
71                 if ((dx >= 0) && (dx < width) && (dy >= 0) && (dy < height)) {
72                    switch (gridArray[dx][dy]) {
73                       case TARGET:
74                          status = Status.ROUTEFOUND;
75                          break;
76                       case EMPTY:
77                          status = Status.CONTINUE;
78                          gridArray[dx][dy] = _step + 1;
79                          break;
80                    }
81                 }
82              }
83           }
84        }
85     }
86
87     return (status);
88  }
89
90  public Route createRoute(int _routeNumber, int _x1, int _y1, int _x2, int _y2) {
91
```


CodeSleuth Disassembled Code View

CodeSleuth Disassembled Code View

Event Data	Address	Hex Bytes	Mnemonic	Operands
	00964ae3	90	nop	
0.98%	00964ae4	bb a8 0f 97 26	mov	%ebx 0x26970fa8
0.02%	00964ae9	8b 9b 58 01 00 00	mov	%ebx [%ebx+0x158]
0.14%	00964aef	3b c3	cmp	%eax %ebx
0.86%	00964af1	0f 84 3e 01 00 00	je	0x00964c35
0.03%	00964af7	8b 59 1c	mov	%ebx [%ecx+0x1c]
0.07%	00964afa	85 05 00 01 3f 00	test	[+0x3f0100 %eax
0.97%	00964b00	3b fb	cmp	%edi %ebx
0.02%	00964b02	0f 8d 2d 01 00 00	jge	0x00964c35
	00964b08	8b 59 08	mov	%ebx [%ecx+0x8]
0.91%	00964b0b	3b 7b 08	cmp	%edi [%ebx+0x8]
0.06%	00964b0e	0f 83 4b 01 00 00	jae	0x00964c5f
0.02%	00964b14	8b 5c bb 0c	mov	%ebx [%ebx+%edi*4+0xc]
0.79%	00964b18	3b 73 08	cmp	%esi [%ebx+0x8]
11.82%	00964b1b	0f 83 50 01 00 00	jae	0x00964c71
0.59%	00964b21	8b 5c b3 0c	mov	%ebx [%ebx+%esi*4+0xc]
24.65%	00964b25	3b da	cmp	%ebx %edx
0.73%	00964b27	0f 85 ea 00 00 00	jne	0x00964c17
	00964b2d	bb 00 00 00 00	mov	%ebx 0x0
	00964b32	90	nop	
	00964b33	90	nop	
	00964b34	ba a8 0f 97 26	mov	%edx 0x26970fa8
	00964b39	8b 92 58 01 00 00	mov	%edx [%edx+0x158]
	00964b3f	3b c2	cmp	%eax %edx
	00964b41	0f 84 d0 00 00 00	je	0x00964c17
	00964b47	85 05 00 01 3f 00	test	[+0x3f0100 %eax

Documentation Views



Demo CodeSleuth

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Demo Closure

- Code uses a large two dimensional array
- The order ‘x by y’ or ‘y by x’ for traversing this array is important when arrays are large (cache implications)
- The original scan order does not take advantage of the cache, in fact it ‘pollutes’ its own cache
- By reordering the scan we can decrease cache pollution and thus improve performance

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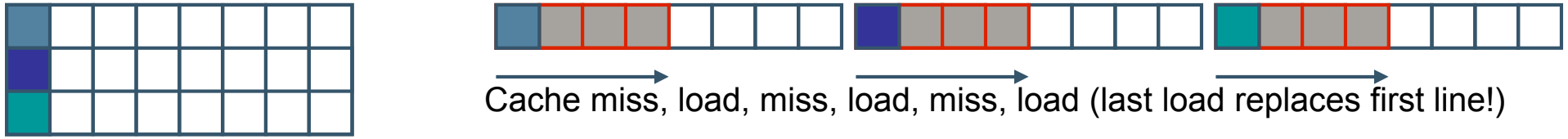
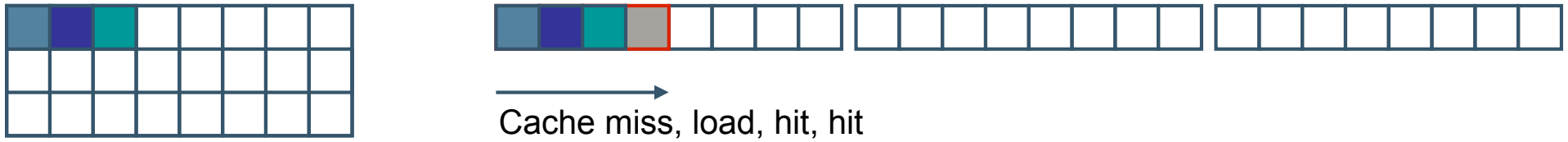
Demo Closure

- If we had 2 cache lines, each of which can hold 4 cells

Y by X (Column Major)



X by Y (Row Major)



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Conclusions

- Hardware performance counters can help reveal performance issues
- CodeAnalyst enables you to analyze CPU level performance of Java applications
- CodeSleuth helps bring the power of this tool into your favorite IDE
- Promote the inclusion of performance analysis as part of your development/test cycle

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CodeSleuth Links

Site

http://developer.amd.com/codesleuth

Source

http://codesleuth.sourceforge.net

Update Site

http://developer.amd.com/codesleuth_1_0_0

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Links

- http://developer.amd.com
  - Software downloads
  - AMD Java Labs blog
  - Forum discussions

- Lee, C.Y., "An Algorithm for Path Connections and Its Applications", IRE Transactions on Electronic Computers, vol. EC-10, number 2, pp. 364-365, 1961

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